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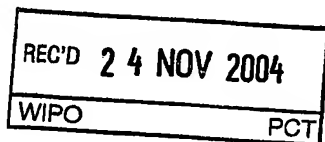
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Patentanmeldung Nr.   Patent application No.   Demande de brevet n°

03104246.8

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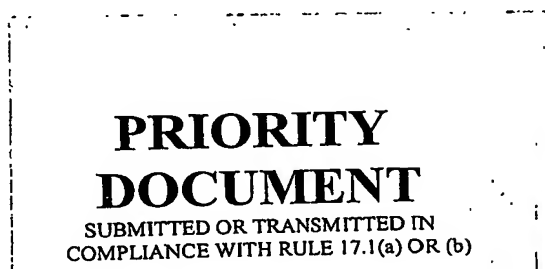
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R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Determining buffer refilling time

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Determining buffer refilling time

The invention relates to a playback device for playback of a media stream stored on a storage medium, the device comprising reading means for reading a part of the media stream, a buffer for holding the part of the media stream, a playback unit for consuming the part of the media stream from the buffer at a predefined rate, and control

5   means for controlling the reading of the media stream from the storage medium, the filling of the buffer and the playback of the media stream.

The invention further relates to a method for playback of a media stream from a storage medium, the method comprising the steps of reading at least a part of the media stream, holding the part of the media stream in a buffer, playing back the part of the media

10   stream from the buffer at a predefined rate, and controlling the reading of the media stream from the storage medium, filling of the buffer and the playback of the media stream.

The invention also relates to a computer program product.

15   The article "Saving energy in portable multimedia storage" by Jan Korst, Joep van Gassel, and Ruud Wijnands, published as chapter 15 (page 261-274) of "Algorithms in ambient intelligence", published in 2003 by Kluwer Academic Publishers describes strategies for saving energy in portable multimedia disk based storage devices.

One strategy of saving energy is putting the storage medium in standby mode

20   after reading part of the media stream, being a video or audio stream. This storage medium can for example be a hard disk drive (HDD) or an optical disk (e.g. CD or DVD). On playback data of the media stream is read from the storage medium into a buffer. Meanwhile a playback unit is consuming data from the same buffer at a predefined rate. When playing back constant bit rate media streams the consumption rate is constant at a fixed amount of

25   bits per second. When playing back variable bit rate media streams the consumption rate varies, depending on the actual bit rate of the part of the media stream to play. When the buffer is almost empty new data is read from the storage medium into the buffer. When the storage medium is for example a HDD, the disk can spin down in order to save energy after the buffer is filled. Just before new data is read from the disk into the buffer the disk is spun

up again. The buffer refilling time is the amount of time between two successive buffer fillings, wherein the disk is spun down, no data is transported from the storage medium to the buffer, and the media stream is consumed from the buffer. For constant bit rate media streams the buffer refilling time is calculated from the bit rate of the media stream and the

5   size of the buffer.

For variable bit rate media streams it is not clear what the actual bit rate of each part of the stream is. For variable bit rate media streams the buffer refilling time is therefore estimated based on the peak bit rate of the entire media stream, which is usually much higher than the average bit rate. Since this is a worst case number, the buffer will

10   generally still contain data when this calculated refilling time has passed. Refilling of the buffer, although perhaps far from empty, will result in a more frequent than necessary spinning up of the disk, resulting in an increase in power consumption.

A better strategy mentioned in said article is to calculate a new buffer refilling time when the buffer does not need a refill at the first calculated refilling time. The refilling

15   time has to be recalculated numerous times and buffer fullness has to be checked frequently. The calculation needs to be done with increasing frequency until the buffer is finally to be refilled.

Determining the buffer refilling time is one of the most complicated tasks of a buffer scheduler and therefore complicates the scheduler design and makes the whole

20   refilling process indeterministic in nature. Checking the buffer fullness too late will cause a buffer under run and will result in the playback unit not being able to present seamless playback.

25   It is an object of the invention to provide a playback device of the kind set forth in the first paragraph which reduces power consumption while minimizing the risk of buffer under runs.

With the playback device of the invention this object is realized in that the control means comprise means for retrieving playback mode control information, and means

30   for calculating a buffer refilling time depending on the playback mode control information.

Playback mode control information is stored with the media stream or elsewhere on the storage medium for playing back the media stream in a selected playback mode. The playback mode control information conditions when a part of the media stream has to be read, transported, decoded or played back when playing back the media stream in a

selected playback mode. Possible playback modes are for example normal speed playback, fast forward, playing backward, skipping parts of the media stream, random playback or slow motion. For different playback modes, parts of the media stream are played back in differently timed sequences depending on the playback mode control information.

5   The moment that each part of the media stream is played back is defined by the playback mode control information and the selected mode of playback. The buffer will be empty when the last part of the media stream is consumed by the playback unit. In this invention playback mode control information concerning the part of the media stream in the buffer is used to determine when the buffer will be empty. When the buffer is refilled before

10   the calculated buffer refilling time, i.e. the moment it would be totally empty, no buffer under run can occur.

            Every time the buffer is filled a calculation of the next buffer refilling time is done, allowing the storage medium to spin down in order to decrease energy consumption. Decreased energy consumption results in saving power and decreasing heat production. Heat

15   production could be harmful to the device. As spinning up of the storage medium is postponed till the buffer refilling time, the number of spin ups and the power needed for spinning up the storage medium will be minimized. The architecture of the scheduler is significantly simplified because no additional checking of the buffer fullness or recalculation of the buffer refilling time is required. The accurate calculation of the buffer refilling time

20   eliminates the chance of the buffer unexpectedly being empty because buffer refilling is done too late, causing a buffer under run.

            This invention relies on the fact that most predefined media stream formats comprise playback mode control information for enabling different playback modes. The playback mode control information is retrieved and used for calculation of the buffer refilling

25   time. The calculation can be done although no specific information for controlling the buffer refilling process is enclosed in such predefined media stream formats.

            In an embodiment of the playback device according to the present invention the playback mode control information is retrieved from characteristic point information.

            Characteristic point information (CPI) comprises tables of locations within the

30   media streams which are suitable for navigating when playing back in different playback modes. For example CPI is enclosed in the predefined logical disc format of Blu-ray Disc, which conditions the way the media stream is stored.

            Another embodiment of the playback device according to the present invention is provided in which the control means are arranged for calculating the amount of

time needed for buffer refilling depending on information concerning retrieval of the media stream.

The calculation of the buffer refilling time is based on the moment in time when the buffer will be totally empty. The process of filling the buffer takes up some time. The refilling of the buffer therefore has to be started some time before the buffer is totally empty and has to be completed at the moment the buffer would be totally empty if no refilling would take place at all. If no information about the amount of time needed for filling the buffer is available, buffer refilling has to start a predefined worst case time period before the buffer would be totally empty. Calculating the amount of time needed for buffer refilling contributes to the accuracy of the determination of the buffer refilling time. A more accurate determination of the buffer refilling time makes it possible to further reduce power consumption while minimizing the risk of buffer under runs.

Another embodiment of the playback device according to the present invention is provided in which the control means are arranged for using information about the location of the part of the media stream on the storage medium for calculating the amount of time needed for buffer refilling.

The location of the content on the storage medium may affect the speed of retrieval. Hard disks and Blu-ray disks for example rotate with a constant angular velocity and a constant information density all over the disk. Thus the outer part of the storage medium, because of its greater diameter has a greater circumference than the inner part of the storage medium. From the outer parts of the storage medium a greater part of the media stream is read per rotation of the storage medium, resulting in a smaller amount of time needed for buffer refilling and less power consumption required for a buffer refilling.

Another embodiment of the playback device according to the present invention is provided in which the control means are arranged for using information about the position of the disk head for calculating the amount of time needed for buffer refilling.

Moving the disk head to the position in which it can read the required part of the media stream costs time. The greater the distance between the disk head and the required part of the media stream, the more time it will cost to refill the buffer.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

In the drawings:

Fig. 1 is a block diagram of an embodiment of a playback device according to the present invention.

Fig. 2 is a schematic presentation of part of a media stream and corresponding CPI-information.

5   Fig. 3 shows the buffer fullness during the reading of a constant bit rate media stream from the storage medium, filling of the buffer and the playback of the media stream.

Fig. 4 shows the buffer fullness for the buffer in a playback device according to the present invention during the reading of a variable bit rate media stream from the storage medium, filling of the buffer and the playback of the media stream.

10

Fig. 1 is a block diagram of an embodiment of a playback device 8 according to the present invention. The playback device 8 comprises reading means for reading a media title from a storage medium 1. The reading means comprises a disk head 2 for accessing the

15   data on the storage medium 1, a motor unit (not shown in Fig. 1) for spinning up the storage medium 1, an actuator (not shown in Fig. 1) for moving the disk head 2 to its reading position and a read unit 3 for controlling the data read out process and processing the data read by the disk head 2. The playback device 8 also comprises a buffer 4, a playback unit 5 and a control unit 6 for controlling the transport of the media stream from the storage medium 1, via the

20   disk head 2 and the read unit 3, to the buffer 4 and finally to the playback unit 5. The control unit 6 encloses a retrieval unit 9 for retrieving playback mode control information 7 and a calculation unit 10 for calculating a buffer refilling time. The playback mode control information 7 is retrieved by the retrieval unit 9 via the disk head 2 and the read unit 3.

Media streams are stored on the storage medium 1. The storage medium 1 may

25   be a hard disk, an optical disk (e.g. CD or DVD) or any other rotary storage medium and may also be an external storage medium coupled to the playback device or a storage medium connected to the playback device via a network. The read unit 3 accounts for the filling of the buffer 4 with data of the media stream. The read unit 3 is controlled by the control means 6 to provide retrieval of the required data of the media stream from the storage medium 1 and

30   supplies the control unit 6 with information about the reading process. The control unit 6 may for example be realized as driver software or hardware implemented by using a dedicated processor and a memory. The buffer 4 is also controlled by the control unit 6 for example to ensure correct timing of the buffer filling or to prevent the device 8 from overwriting information in the buffer 4 that still has to be played back. Information about the buffer 4 and

the contents of the buffer 4 is supplied to the control unit 6. The control unit 6 also controls

the transport of the media stream from the buffer to the playback unit 5 and the actual

playback of the media stream. The control information for the transport of data of the media

stream from the buffer 4 to the playback unit 5 for example defines the rate at which the

5   media stream is consumed from the buffer 4 and the playback sequence for different media

streams or parts of media streams.

Playback mode control information 7 is enclosed in predefined media stream

formats and is for example used by the control unit 6 to retrieve the required part of the

media stream from the storage medium 1, to define the rate at which the media stream is

10   consumed from the buffer 4 and to define the playback sequence for different media streams

or parts of media streams, depending on the selected playback mode. In the playback device

8 according to the present invention the playback mode control information 7 is also used to

determine when the last part of the media stream will be consumed from the buffer 4 and

when the buffer 4 has to be refilled in order to minimize power consumption and to provide

15   seamless playback by the playback unit 5. In the embodiment shown in Fig.1 the playback

mode control information 7 is stored with the media stream data on the storage medium 1.

The disk head 2 reads the playback control information from the storage medium 1 and via

the read unit 3 the playback control information is passed to the retrieval unit 9, which

extracts the useful information and passes it on to the calculation unit 10. The playback mode

20   control information 7 may also be retrieved from system memory (not shown in Fig. 1).

In an embodiment according to this invention this playback mode control

information 7 is retrieved from characteristic point information 32. Fig. 2 shows part of a

media stream file 31 and a corresponding part of the characteristic point information (CPI)

32. CPI comprises tables of and pointers 33 to locations within the media streams 31 which

25   are suitable for navigating when playing back in different playback modes. CPI is used to

determine the location of entry points (P1, P2, P3) for trick play (for example fast forward,

fast reverse), interactive play (user chooses where to start playing a media stream) or simple

editing involving clip truncation. Information about an entry point in the media stream is

stored in the CPI. For an entry point the CPI can for example store the location of the entry

30   point in the media stream or the presentation time of the part of the media stream starting at

the entry point. When in fast forward mode specific CPI entry points may be used for

navigating through the frames to be displayed. The CPI is stored separate from the media

stream, e.g. in a special area of the storage medium or in a special file. In order to use CPI

effectively, the CPI data has to be cached in system memory, so that there is no need to read

or write CPI data from or to disc during time critical operations. CPI is enclosed in most predefined logical disk formats and is described in more detail in the above referenced application published as WO00/28544. The usage of other sources of playback mode control information 7 is within the scope of the present invention.

5   In a further embodiment of the playback device 8 the calculation unit 10 is arranged for calculating the amount of time needed for buffer refilling depending on information concerning retrieval of the media stream. This information is for example information about the location of the required part of the media stream on the storage medium 1 or information about the position of the disk head 2. The information about the

10   location of the part of the media stream on the storage medium 1 is for example retrieved from file system info stored on the storage medium 1. The file system info may also be temporarily stored in system memory (not shown in Fig. 1) from which it can be retrieved. Information about the position of the disk head 2 is for example deduced from the last addresses read from the disk 1.

15   The playback unit 5 consumes the media stream from the buffer and transfers the media stream data to a decoding unit. The playback unit may comprise a decoding unit for decoding the encoded media stream and a display and/or a speaker for presenting the media stream to a user. The display unit or speaker unit may also be an external unit coupled to a playback device comprising the decoding unit. The device may for example be part of a

20   home network, while the display unit or speaker unit is wirelessly coupled to the network. In another embodiment the decoding unit is an external unit. In this case the media stream is retrieved from the storage medium, held by the buffer and then sent onto the network to the external decoding unit.

        With an embodiment of the invention it is possible to simultaneously playback

25   more than one media stream or to playback a media stream while recording another media stream. In this case the buffer refilling time may be used to allow the device to read or write data from or onto the storage medium in a secondary process, when the storage medium is not needed for a primary playback process. Calculations of the buffer refilling time are made for all streams. The control unit is arranged for preventing different buffer filling periods to

30   overlap. The control unit 6 is also arranged for refilling a buffer in time for preventing the buffer to run out of data concerning one of the simultaneously played media stream.

        Fig. 3 shows the buffer fullness during the reading of a constant bit rate media stream from the storage medium, filling of the buffer and the playback of the media stream. In Fig. 3 the CBR buffer emptying 24, i.e. the emptying of the buffer during playback of a

constant bit rate media stream, is indicated by a line segment. The filling of the buffer 25 when retrieving the media stream from the storage medium is also indicated by a line segment. The total CBR consumption time 21 is the amount of time needed to consume all data of the constant bit rate media stream held in the buffer. The buffer filling period 22 is the

5   amount of time needed for the filling of the buffer. The total CBR consumption time 21 and the buffer filling period 22 are indicated by arrows. The CBR buffer refilling time 23 is also represented by an arrow. The moment that buffer fullness starts to increase due to refilling of the buffer is shown in the figure and indicated by the buffer refilling point 26.

        When the buffer is completely filled, the playback unit starts consuming the

10   media stream from the buffer. During playback the CBR buffer emptying 24 occurs at a constant rate resulting in a straight line in Fig. 3. As the playback unit consumes the media stream from the buffer at a constant rate and the size of the buffer is known, the total CBR consumption time 21 can be determined. During the filling of the buffer with data of the media stream, retrieved from the storage medium, the buffer fullness increases. The filling of

15   the buffer takes a certain amount of time. This amount of time is the buffer filling period 22. Buffer refilling must be completed when all of the part of the media stream in the buffer is consumed. When the buffer filling period 22 is not known exactly, a worst case value should be estimated, to minimize the chance of buffer under runs. The buffer refilling time 23 equals the total CBR consumption time 21 minus the buffer filling period 22. After filling of the

20   buffer, the next CBR buffer refilling time 23 is determined and the storage medium spins down in order to decrease energy consumption. When the CBR buffer refilling time 23 is elapsed, the storage medium is spun up again to enable buffer refilling.

        Fig. 4 shows the buffer fullness for the buffer in a playback device according to the present invention during the reading of a variable bit rate media stream from the

25   storage medium, filling of the buffer and the playback of the media stream. In Fig 4 the total CBR consumption time 21, the buffer refilling period 22, the CBR buffer emptying 24, the filling of the buffer 25 and the buffer refilling point 26, correspond to Fig. 3. The process of filling of the buffer and the buffer refilling period are the same for constant and variable bit rate media streams. The process of emptying the buffer and the total consumption time are

30   not the same for constant and variable bit rate media streams. The VBR buffer emptying 29, i.e. the emptying of the buffer during playback of a variable bit rate media stream, is indicated by a curved line segment. The total VBR consumption time 27 for the playback of a variable bit rate media stream is indicated by an arrow. The VBR buffer refilling time 28

equals the total VBR consumption time 27 minus the buffer filling period 22 and is also represented by an arrow.

For variable bit rate media streams it is not clear what the actual bit rate is. Each little part of the media stream has its own bit rate. Some parts of the media stream have a high bit rate, resulting in fast emptying of the buffer. Other parts of the media stream have a low bit rate, resulting in slow emptying of the buffer. The variation in bit rate causes the line segment, representing the VBR buffer emptying 29, not to be a straight line like the line segment representing the CBR buffer emptying 24, but to have an irregular shape.

Because of the irregular shape of line segment 29 it is not possible to know exactly when the buffer will be empty without any extra information. In this invention the extra information comes from playback mode control information.

The playback mode control information comprises timing information to define the playback sequence of different parts of the media stream depending on the selected playback mode. This timing information may for example define the moment of retrieval from the storage medium, decoding or playing back the different parts of the media stream. The buffer will be empty when the last part of the media stream in the buffer is consumed by the playback unit. The total VBR consumption time 27 is determined depending on timing information concerning the different parts of the media stream in the buffer to be played back. For example when playing back in a fast forward playback mode with twice the speed of real time playback, the total VBR consumption time 27 equals half the time interval spanned by the timing information concerning the first and the last part of the media stream in the buffer to be played back. From the total VBR consumption time 27 and the buffer refilling period 22 the VBR buffer refilling time 28 is calculated. After the buffer is filled, the device can be brought into a low power consuming mode. The accurate calculation of the buffer refilling time 28 makes it possible to maintain the low power consuming mode for as long as possible, without the risk of buffer under runs. Hence power consumption is minimized.

Although the description of the invention mainly focuses on power consumption reduction, the calculating of the buffer refilling time for variable bit rate media streams may also serve other purposes. For example the buffer refilling time may be used to allow the device to read or record other data, e.g. best-effort data or other real-time streams, from or onto the storage medium in a secondary process, while the storage medium is not needed for a primary playback process.

It is noted, that in this document the word 'comprising' does not exclude the presence of other elements or steps than those listed and the word 'a' or 'an' preceding an element does not exclude the presence of a plurality of such elements, that any reference signs do not limit the scope of the claims, that the invention may be implemented by means of both hardware and software, and that several 'means' may be represented by the same item of hardware. Further, the scope of the invention is not limited to the embodiments, and the invention lies in each and every novel feature or combination of features described above.

CLAIMS:

1.   A playback device (8) for playback of a media stream from a storage medium (1), the device comprising reading means (3) for reading at least a part of the media stream, a buffer (4) for holding the part of the media stream, a playback unit (5) for consuming the part of the media stream from the buffer (4) at a predefined rate, and control means (6) for controlling the reading of the media stream from the storage medium (1), filling of the buffer (4) and the playback of the media stream, which control means (6) comprise means (9) for retrieving playback mode control information (7), and means (10) for calculating a buffer refilling time (28) depending on the playback mode control information.

2.   A playback device (8) as claimed in claim 1, wherein the means for retrieving playback mode control information (7) are arranged for retrieving characteristic point information and the means for calculating the buffer refilling time (28) are arranged for calculating the buffer refilling time (28) depending on the characteristic point information.

3.   A playback device (8) as claimed in claim 1, in which the control means (6) are arranged for calculating the buffer filling period (22) depending on information concerning retrieval of the media stream.

4.   A playback device (8) as claimed in claim 3, in which the control means (6) are arranged for calculating the buffer filling period (22) depending on information about the location of the part of the media stream on the storage medium (1).

5.   A playback device (8) as claimed in claim 3, in which the control means (6) are arranged for calculating the buffer filling period (22) depending on information from the file system info.

6.   A playback device (8) as claimed in claim 4, in which the control means (6) are arranged for calculating the buffer filling period (22) depending on information about the position of a disk head (2).

7.   A playback device (8) as claimed in claim 1, in which the control means (6) are arranged for turning the device (8) in a low power consuming mode for a time interval depending on the buffer refilling time (28).

5

8.   A method for playback of a media stream from a storage medium, the method comprising the steps of reading at least a part of the media stream, holding the part of the media stream in a buffer, playing back the part of the media stream from the buffer at a predefined rate, and controlling the reading of the media stream from the storage medium,

10   filling of the buffer and the playback of the media stream, which step of controlling comprises the sub steps of retrieving playback mode control information, and calculating a buffer refilling time (28) depending on the playback mode control information.

9.   A method as claimed in claim 8, comprising the step of calculating the buffer

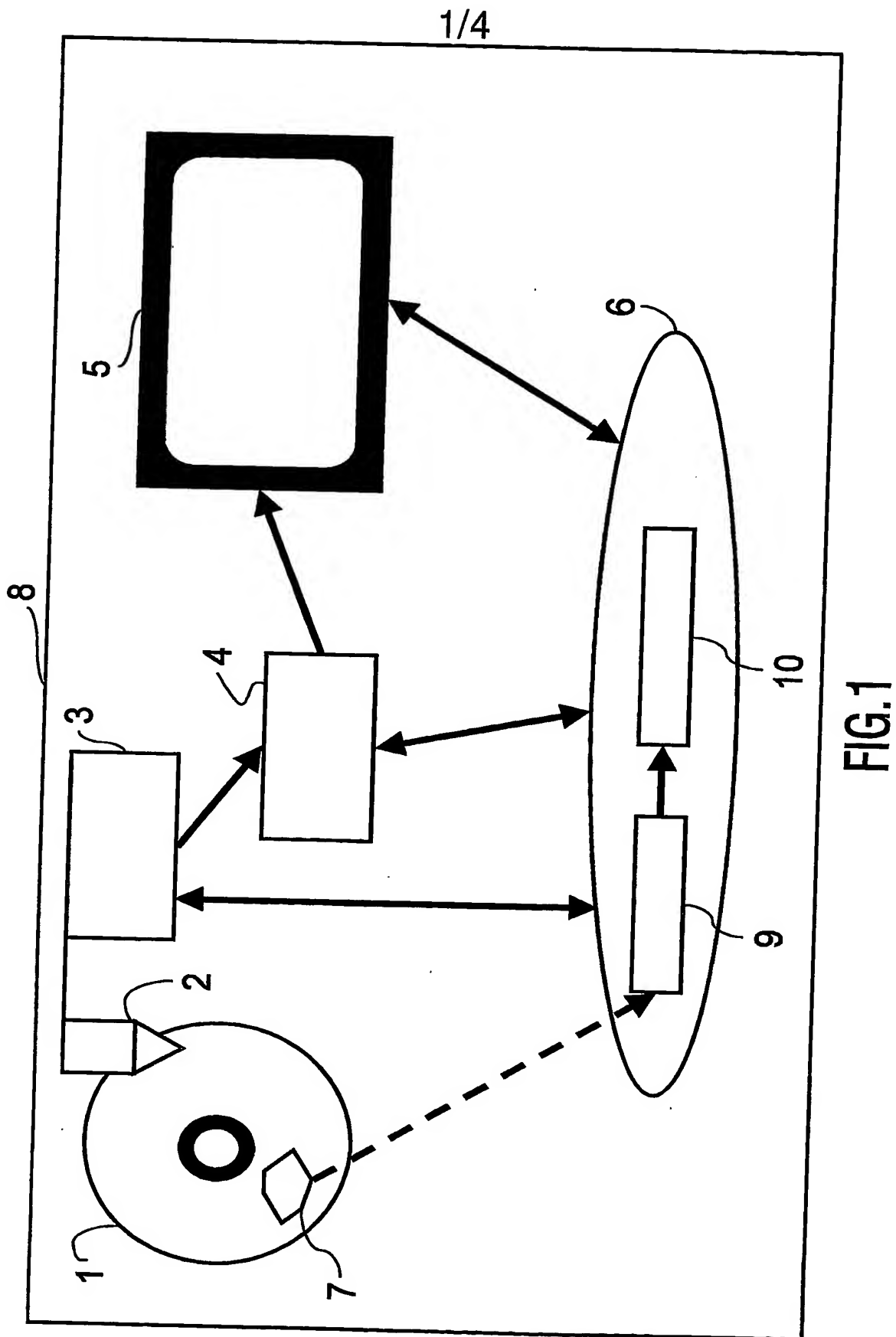15   filling period (22) depending on information concerning the retrieval of the media stream.

10.   A computer program product which program is operative to cause a processor to perform the method as claimed in claim 8.

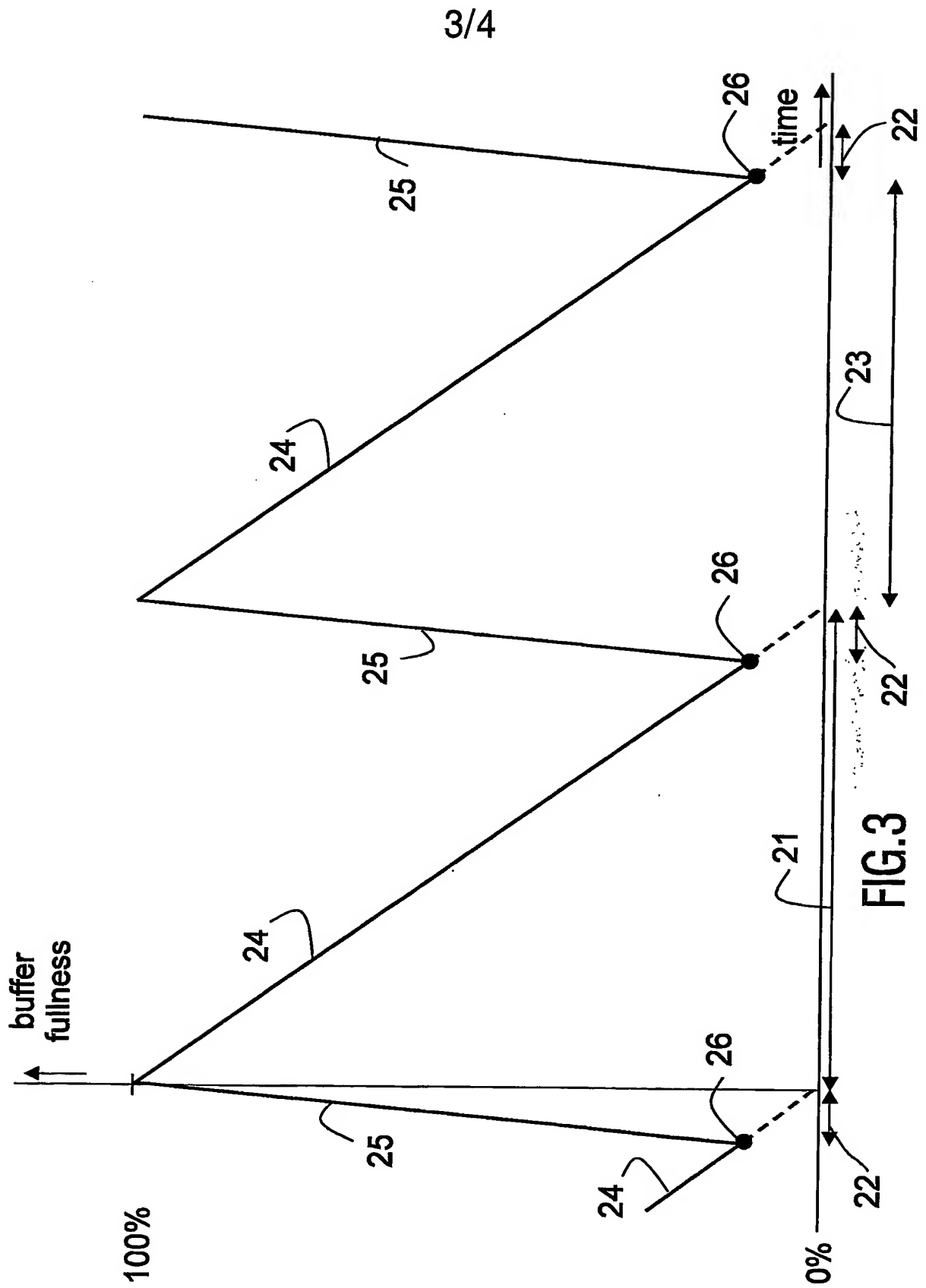13   11.11.2003

ABSTRACT:

A playback device for playback of a media stream stored on a storage medium, the device comprising control means for controlling the reading, buffering and playback of the media stream. During playback a buffer is filled by reading means and emptied by a playback unit. At each buffer filling a buffer refilling time, i.e. the moment
5   when the buffer will be empty and thus has to be refilled, is calculated. After each buffer filling the storage medium can change to standby mode till buffer refilling is to occur. Thus power consumption by the storage medium is minimized.

The buffer refilling time (28) depends on the total consumption time (27) and the buffer filling period (22). The total consumption time (27) is determined depending on
10   playback mode control information. The buffer filling period (22) is calculated depending on information about the retrieval of the media stream or an estimation of the buffer filling period (22) is made.
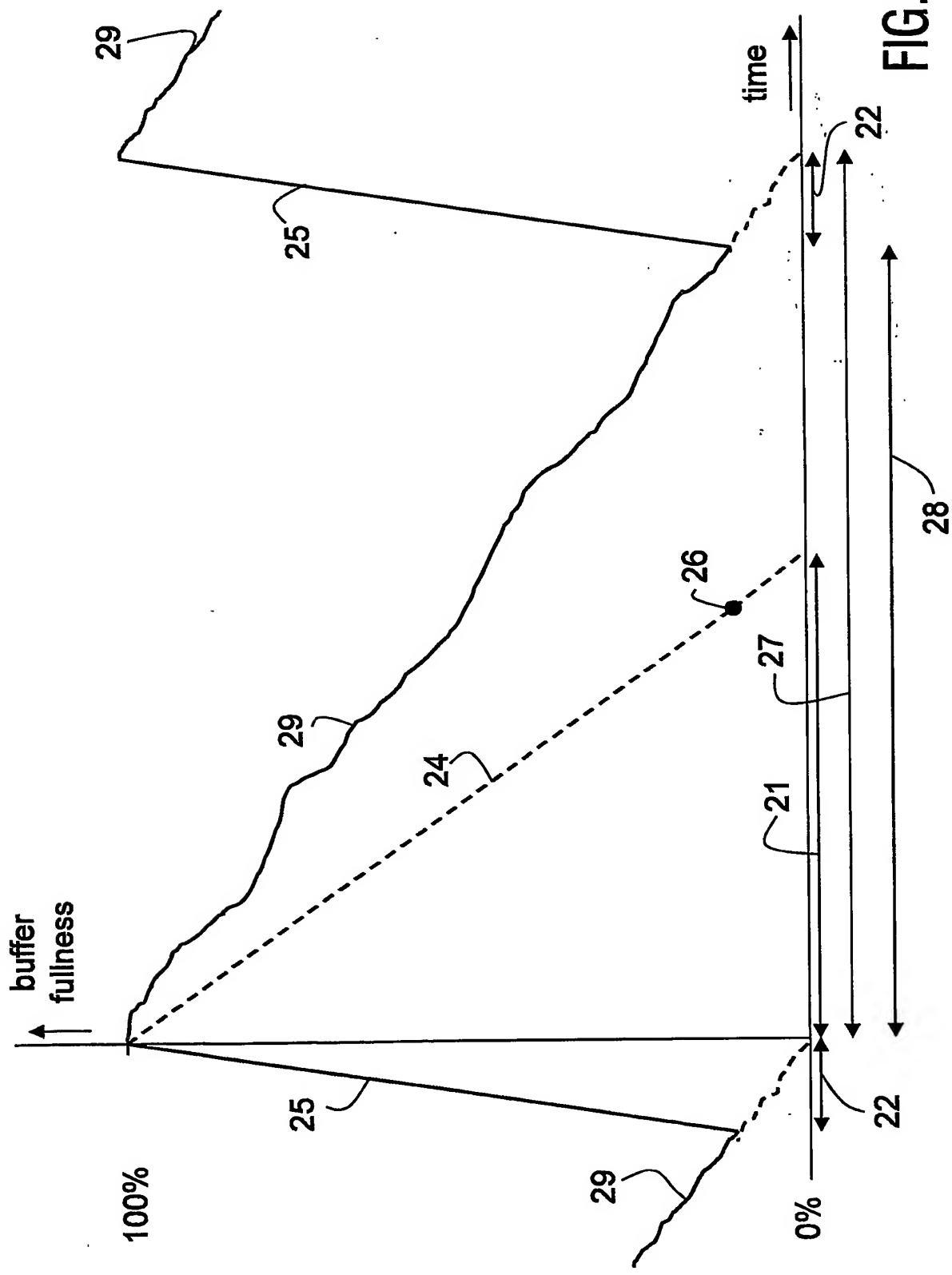
Fig. 4

1/4

FIG.1

PHNL031339

FIG.3

FIG.4